

## Chapter 2 Outline: *Motion in One Dimension*

### I. Displacement and Velocity

#### A) Motion

1. One-dimensional motion is the simplest form of motion
  - a) can only move “forwards” or “backwards”
  - b) for example, a train on a track
2. Motion takes place over time and depends on the frame of reference
  - a) **frame of reference** – a system for specifying the precise location of objects in space and time
  - b) a reference frame is fixed and has an origin from which motion is measured
  - c) an object at rest does not change with respect to a fixed frame of reference
  - d) any frame of reference can be chosen as long as it is used consistently, though some can make explaining things easier than others

#### B) Displacement

1. **displacement** – the change in position of an object
2. Displacement is a change in position
  - a) one-dimensional displacement is the difference between the final and initial coordinates
  - b)  $\Delta$  before a variable is used to denote a change in the position of an object
3. Displacement is not always equal to the distance traveled
  - a) displacement is only the distance between the start and end points
4. Displacement can be positive or negative
  - a) positive is the right (east) or upward (north) direction
  - b) negative is the left (west) or downward (south) direction

#### C) Velocity

1. Average velocity is displacement divided by the time interval
  - a) **average velocity** – the total displacement divided by the time interval during which the displacement occurred
  - b) in SI, the unit of velocity is meters per second (m/s)

- c) the average velocity has the same sign as the displacement
- 2. Velocity is not the same as speed
  - a) velocity describes motion with both a direction and a numerical value (magnitude) indicating how fast something moves
  - b) speed has no direction, only magnitude
  - c) **average speed** – the distance traveled divided by the time interval during which the traveling occurred
- 3. Velocity can be interpreted graphically
  - a) represented in a position-time graph
  - b) time is plotted on the horizontal axis, and position on the vertical axis
  - c) average velocity can be determined by drawing a straight line between any two points on the graph
- 4. Instantaneous velocity may not be the same as average velocity
  - a) **instantaneous velocity** – the velocity of an object at some instant or at a specific point in the object's path
  - b) the velocity of an instant is equal to the slope of a line to the graph at that point

## II. Acceleration

### A) Changes in Velocity

- 1. Acceleration is the rate of change of velocity with respect to time
  - a) **acceleration** – the rate at which velocity changes over time; an object accelerates if its speed, direction, or both change
  - b) acceleration can be calculated by dividing the total change in an object's velocity by the interval in which the change occurs
  - c) acceleration is expressed in dimensions of length divided by time squared
    - i. in SI, this is expressed as  $\text{m/s}^2$
- 2. Acceleration has direction and magnitude
  - a) velocity increases in magnitude as a train picks up speed
  - b) velocity decreases in magnitude as a train loses speed
- 3. The slope and shape of the graph describe the objects' motion
  - a) when velocity is increasing, acceleration is positive
  - b) when velocity is constant, there is no acceleration

- c) when velocity is decreasing, acceleration is negative
- d) a negative value for acceleration could indicate a decrease in speed, or a negative direction

#### B) Motion with Constant Acceleration

1. where velocity increases by the same amount each time interval, acceleration is constant
2. Displacement depends on acceleration, initial velocity, and time
  - a) displacement =  $\frac{1}{2}(\text{initial velocity} + \text{final velocity})(\text{time interval})$
3. Final velocity depends on initial velocity, acceleration, and time
  - a) final velocity = initial velocity + (acceleration \* time interval)
  - b) displacement = (initial velocity \* time interval) +  $\frac{1}{2}\text{acceleration} * (\text{time interval})^2$
4. Final velocity depends on initial velocity, acceleration, and displacement
  - a)  $(\text{final velocity})^2 = (\text{initial velocity})^2 + 2(\text{acceleration})(\text{displacement})$

### III. Falling Objects

#### A) Free Fall

1. Freely falling bodies undergo constant acceleration
  - a) disregarding air resistance, all objects dropped near the surface of a planet fall with the same constant acceleration
  - b) free fall** – the motion of a body when only the force due to gravity is acting on the body
  - c) acceleration due to gravity is denoted with the symbols  $a_g$  (generally) or  $g$  (on Earth's surface)
    - i. the magnitude of  $g$  is about  $9.81 \text{ m/s}^2$
  - d) acceleration of objects in free fall near the surface of the earth is  $-g$
2. Acceleration is constant during upward and downward motion
  - a) objects thrown into the air have a constant downward acceleration as soon as they are released,  $-g$
3. Freely falling objects always have the same downward acceleration
  - a) free-falling objects have a downward acceleration of  $-g$